

RECLAMATION

Managing Water in the West

Final Report – September 30, 2015

Safety in the Design Process

Safety and Occupational Health

Program Action Plan Team #20 Recommendations



Mission Statements

The mission of the Department of the Interior is to protect and provide access to our Nation's natural and cultural heritage and honor our trust responsibilities to Indian Tribes and our commitments to island communities.

The mission of the Bureau of Reclamation is to manage, develop, and protect water and related resources in an environmentally and economically sound manner in the interest of the American public.

Safety in the Design Process

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Safety and Occupational Health Related Design Criteria

Acronyms

A-E	Architect-Engineering
AHJ	Authority Having Jurisdiction
AHJT	Authority Having Jurisdiction Team
ANSI	American National Standards Institute
CE/CM	Construction Engineer/Construction Manager
D&S	Directives & Standards
DASHO	Designated Agency Safety and Health Official
DDR	Design Data Request
DfCS	Design for Construction Safety
FDP	Final Design Process
GSA	U.S. General Services Administration
IBC	International Building Code
IFC	International Fire Code
LSC	Life Safety Code
NFPA	National Fire Protection Association
NIOSH	National Institute for Occupational Safety and Health
NPS	National Park Service
O&M	Operations and Maintenance
OSHA	Occupational Safety and Health Administration
PM	Project Manager
PPE	Personal Protective Equipment
PtD	Prevention through Design
RDCCT	Reclamation Design and Construction Coordination Team
RLT	Reclamation Leadership Team
RM	Reclamation Manual
RSHS	Reclamation Safety and Health Standards
SOH	Safety and Occupational Health
SSLE	Security, Safety and Law Enforcement
TSC	Reclamation's Technical Service Center
USACE	U.S. Army Corps of Engineers
VE	Value Engineering

Definitions

Authority Having Jurisdiction (AHJ)

A designated individual responsible for interpreting Life Safety Code requirements and approving equivalent levels of safety, exemptions, installations, equipment, and procedures.

Design

Includes new design, redesign, modifications and rehabilitation, modifications to existing features by O&M staff, and changes during construction.

Design for Construction Safety (DfCS)

The process of addressing construction site safety and health in the design of a project.

Facilities

Structures associated with Reclamation irrigation projects, municipal and industrial water systems, and power generation; including all storage, conveyance, distribution, and drainage systems. In this report, facilities also include the machinery, tools, and equipment required to operate and maintain the facility.

Life Safety Code (LSC)

National Fire Protection Association (NFPA 101) Life Safety Code Handbook

Prevention through Design (PtD)

Process for addressing occupational safety and health needs in the design and redesign process to prevent or minimize the work-related hazards and risks associated with the construction, manufacture, use, maintenance, retrofitting, and disposal of facilities, processes, materials, and equipment.

Safety and Occupational Health

An area concerned with safety, health and welfare of people engaged in work or employment with a focus on minimizing hazards

Safety Professional

An individual who, by virtue of education, training, certification, and experience has achieved professional status in the safety field.

Executive Summary

The genesis of Safety Action Team 20 resulted from the Bureau of Reclamation's (Reclamation) Safety Action Plan Team identifying certain Reclamation facilities that were constructed or being operated without essential safety systems and engineering controls in place to address the hazards associated with the operations for which they were designed and intended. To address these observations, Safety Action Team 20 was formed to assess Reclamation's current processes for ensuring safety and occupational health (SOH) through design, and to identify improvements to current processes. This report documents Safety Action Team 20's findings and recommendations to improve SOH through Reclamation's design process.

The Team concludes the following:

- The responsibility for ensuring SOH features are provided and maintained at Reclamation facilities is identified and applied across many Reclamation documents, organizations, and disciplines which can lead to a lack of coordination and missed opportunities to cost-effectively improve the SOH of facilities during design.
- Reclamation has strong safety, design, and construction cultures. While the safety organization is well integrated into the construction process, it is not well integrated into the design process. Further, the responsibilities of the Authority Having Jurisdiction (AHJ) are not well understood across the agency.
- The sunseting of Reclamation policy in 1994 has created a void in internal safety design guidance that has not been properly addressed by current Reclamation Manual (RM) [1] documents and design criteria. No clear guidance is available to assist designers in Reclamation specific design criteria and the incorporation of national standards into design work.
- Reclamation has a well-defined final design process (FDP) that is focused on technical adequacy, constructability, and cost. Generally designers and project owners consider SOH a high priority; however, there is no formal process during final design for identifying potential hazards in construction, operation, maintenance and decommissioning; evaluating risks associated with the hazards; and assessment of design options to potentially eliminate or mitigate for hazards.
- The success of improving the overall safety of Reclamation facilities requires effective communication, coordination, and collaboration among Reclamation's safety, design,

construction, and O&M communities, and strong support from Reclamation's Leadership Team (RLT).

- One of the best ways to prevent and control occupational injuries, illnesses, and fatalities is to “design out” hazards. Prevention through Design (PtD) is a formal approach using hierarchy of controls and risk assessment to identify project hazards early in the design process and working to eliminate these hazards, or find design alternatives that mitigate the hazard so the risk of injury is at an acceptable level.
- Implementation of a formal PtD program is one additional step Reclamation can take to help improve the SOH of our facilities. To be effective, SOH measures incorporated in the initial designs need to remain in place and/or be modified as necessary during the life of the facility.

The team recommends the RLT approve the following actions to improve the SOH design of Reclamation facilities and integrate PtD concepts into Reclamation's design culture:

1. Revise the Reclamation Manual [1] as follows:
 - a. Create a new Directive and Standard (D&S) under SAF P01 identifying AHJ responsibilities. (See Appendix G of the 2008 Life Safety Code Compliance Review Report [2]).
 - b. Revise D&S FAC 01-05 to require participation of a safety professional on transfer inspection teams.
 - c. Revise FAC 03-03 to identify AHJ design responsibilities and a clear means to integrate AHJs into the design process.
2. Assign a Team to review and revise Reclamation's Design Data Collection Guidelines [3] to increase focus on design provisions to improve SOH practices during construction and operations, and to solicit client and stakeholder input regarding SOH preferences above minimum requirements. Include identification of existing hazards (energy, materials, access, etc.), identification of hazards during construction, required contractor safety representation during construction, and identification of post-construction hazards.
3. Maintain focus on Reclamation formal design standard updates and include SOH information in Design Standards No. 1 through 14 as appropriate.
4. Establish a team to prepare a “Reclamation Safety Design” guidance document that can be used by designers to complement existing Reclamation and national standards they currently use to perform their work. This document could be modeled after Design Standard No. 1, Chapter 3, *Safety Design Standards* [4] and should identify

feature specific minimum safety criteria with references to appropriate codes. It should be prepared by a team with representation from Reclamation's design, construction, O&M, and safety communities.

5. The RLT should institute a Reclamation-wide PtD program and establish a PtD Implementation Team. The goal of the PtD Implementation Team would be to integrate PtD into Reclamation's design process to identify hazards, evaluate methods to avoid and/or eliminate identified hazards, or reduce the risks to acceptable levels. The team should have representation from Reclamation's design, construction, O&M, and safety communities. Once established, the PtD Implementation Team should:
 - a. Develop Reclamation facility-specific Hazard Review Checklists for designers and other SOH review team members to use in PtD hazard risk assessments. The Checklists should include an assessment of the potential for noise-induced hearing loss of occupants that could be mitigated through application of "Buy Quiet" principles.
 - b. Conduct a comprehensive review of historical accident and near-miss reports. For incidents where a design weakness/deficiency caused or contributed to the incident, the design deficiency should be included in the Hazard Review Checklist. If a design or process modification was implemented to eliminate or mitigate the hazard, this corrective action information should also be documented.
 - c. Formalize a process for gathering lessons learned during construction and operation of facilities from design, construction, O&M, and safety personnel. Lessons learned that make future projects safer should be included in the Hazard Review Checklist.
 - d. Develop guidance documents and conduct training to facilitate integration of PtD into Reclamation's design culture.
6. Request the Reclamation Design and Construction Coordination Team (RDCCT) to revise the Final Design Process (FDP) Guidelines to include:
 - a. PM formation of a SOH review team comprised of representatives from design, construction, safety, O&M, and others with specialized knowledge of the project to conduct a PtD hazard risk assessment during final design to consider SOH in construction, operation, and maintenance.
 - b. Creation of a Milestone for PtD hazard risk assessment near the 30% Final design milestone (CONCEPTC).
 - c. O&M staff participation during the draft specifications review stage (REVIEWC) to focus on SOH provisions.

- d. Safety Office personnel participation during the draft specifications review stage (REVIEWC) to not only focus on construction safety, but also operator safety.
 - e. Creation of a milestone for Post-Project Review to gather lessons learned and identify SOH improvements for future, similar facilities.
- 7. Request the Facilities Operation and Management Team to work with the RDCCT to establish a well-defined, efficient process for O&M personnel to obtain input from Reclamation's design community when they are contemplating field modifications that could represent a deviation from the original design intent. The process should permit an opportunity for a Reclamation safety professional to evaluate possible impacts the modifications may have on the SOH of the facility.

Introduction

On January 24, 2014, in response to an agency-wide review by the U.S. Department of the Interior Office of Occupational Safety and Health, a Reclamation-wide team was formed to address concerns about the safety and health of Reclamation employees, contractors, and visitors. This Team published the *Safety and Occupational Health (SOH) Action Plan* in May 2014 [5] which identified a set of 21 actions to encourage everyone to conduct their daily work in an efficient, safe, and healthful manner. Safety Action Task 20 targets safety in design as follows:

Evaluate and implement strategies for addressing safety through design activities including the following key components:

- *Assess the adequacy of Reclamation directives, standards, and guidance documents.*
- *Compare Reclamation's approach with other agency approaches in addressing SOH issues during the design process.*
- *Assess the current specifications review process to ensure SOH issues are being fully considered.*

This report documents Safety Action Team 20's findings and recommendations to improve SOH throughout Reclamation's design process. It includes discussion of Reclamation design responsibilities, design criteria, and design process. Facilities designed, constructed, and operated by Reclamation include: powerplants, pumping plants, office buildings, warehouses, canals, pipelines, tunnels, dams, spillways, outlet works, roads and bridges, water and wastewater treatment facilities, and fish facilities.

Reclamation Design Responsibilities

Design activities are performed within Reclamation to develop and maintain project infrastructure, address new initiatives, respond to emergencies, and provide technical assistance in support of the agency's mission. Coordination of design activities among all Reclamation offices, including regional offices, area offices, construction offices, and the Technical Service Center (TSC) is essential to ensure that design activities are performed in a professional, timely and cost-effective manner that satisfies all technical and SOH requirements.

Current Practice

Responsibilities for Reclamation design activities are identified in various Reclamation Policies, and Directives and Standards (D&S). Distribution of design work is governed by RM [1] D&S *Workload Distribution Practices for Technical Services Work* (CMP 10-03) and performance of design work is governed by RM Policy *Performing Design and Construction Activities* (FAC P03) and RM D&S *Design Activities* (FAC 03-03).

CMP 10-03 assigns agency directors the responsibility for determining how technical services are obtained for Reclamation projects and programs. Program Offices are responsible for identifying the preferred service provider for technical services work, including design services. Reclamation service providers are the providers of choice for technical services work. In RM D&S *Design Activities* (FAC 03-03), Regional Directors are assigned the responsibility for accomplishment of Reclamation programs involving design activities within their regions. It also assigns the TSC Director the responsibility for establishing and maintaining design criteria and engineering and technical standards for all Reclamation design work.

At the initiation of a design project, a Program Office appoints a Project Manager (PM) responsible for the overall coordination of the project from inception through construction. The PM is responsible for coordinating among internal and external stakeholders and facilitating effective communications between service providers and the program office (RM D&S *Project Management* [CMP 07-01]). Design activities are typically performed by a Reclamation design team under the direction of a design team leader. Working with the PM, the team identifies schedules, budgets, and design data requirements, and is responsible for ensuring that the work receives the proper coordination and technical reviews. It is the design team's responsibility to ensure that designs developed by Reclamation incorporate an appropriate level of features to provide safety during construction and operation, and that these features are adequately defined in the construction specifications paragraphs, drawings, and written reports such as the Design Summary and Designer's Operating Criteria.

During construction, RM D&S *Construction Activities* (FAC 03-02) assigns to the Construction Engineer/Construction Manager (CE/CM) the responsibility for administering construction activities and ensuring implementation of the design intent and compliance with the contract specifications. For new construction, RM D&S *Transfer of Operation and Maintenance Responsibility of Project Works* (FAC 01-05) identifies a formal process that transfers project works from construction to O&M status. Participation in transfer inspections is determined by the office in charge of construction based on whether the facility was a safety of dams modification, and/or constructed under Denver- or Regional-issued specifications. Typically, one or more representatives from the design team participate on transfer inspections. For construction work

performed on existing facilities that remain in O&M status, a similar inspection process including the CE/CM and responsible PM is generally followed.

Once in O&M status, RM Policy *Power Operation and Maintenance Technical Standards* (FAC P14) assigns responsibility for maintaining power facilities in a safe manner to the Area or Facility Manager.

RM Policy *Safety and Occupational Health Program* (SAF P01) identifies the Deputy Commissioner for Policy, Administration, and Budget as Reclamation's Designated Agency Safety and Health Official (DASHO). The DASHO provides executive-level policy and SOH program direction and guidance. SAF P01 also assigns responsibility for the overall development, implementation, and management of Reclamation's SOH program to the Director of Security, Safety, and Law Enforcement (SSLE).

On December 18, 2008, the SSLE Director transmitted the *Life Safety Code Compliance Review Report* [2] to Reclamation's Leadership Team (RLT). This report identified a new position within each Reclamation region: the Authority Having Jurisdiction (AHJ). Consistent with the NFPA Life Safety Code (LSC) (NFPA 101), AHJ responsibilities include:

- Enforcing the requirements of NFPA 101,
- Determining whether the provisions of NFPA 101 are met,
- Determining requirements not specifically provided for by NFPA 101 that are essential for the safety of facility occupants,
- Modifying NFPA 101 requirements that are deemed to be impractical when reasonable safety is provided,
- Adopting minimum qualifications for all persons administering and enforcing NFPA 101, and
- Rendering interpretations of NFPA 101 and making and enforcing rules and regulations to carry out the code intent.

On November 24, 2010 the SSLE Director transmitted the *Life Safety Code Implementation Plan* (Plan) to the RLT [6]. The Plan outlined actions to ensure Reclamation adequately addresses its Occupational Safety and Health Administration (OSHA) and LSC obligations, and required that each Regional Director identify a single point of contact as their region's AHJ. The Plan also created a Reclamation-wide Authority Having Jurisdiction Team (AHJT) comprised of AHJs from each Region and an AHJ facilitator from the Reclamation Safety Office. The AHJT was formed to provide a collaborative forum to discuss LSC interpretations having Reclamation-wide impact.

Evaluation

Reclamation has a strong safety, design, and construction culture; however, its SOH and LSC personnel are not well integrated into the design process. The PM has the responsibility of ensuring stakeholder needs for SOH related items are communicated to the design team. The design team and its technical approvers are responsible for including SOH features that meet the minimum requirements identified in Reclamation design criteria, and other measures identified during the design process, or requested by clients and stakeholders to improve the construction and operational safety of the facility. Where disagreements arise between PM, stakeholder, and designer interpretations of LSC requirements, regional AHJs have the responsibility of deciding the final interpretation. Efforts by SSLE to establish a team of AHJs in 2008 and 2010 have led to identification of regional AHJs, but there appears to be no clear understanding of the position's role and responsibilities during the design process.

During the life of a facility, the responsibility for ensuring implementation of appropriate SOH measures transitions from the design entity, to the construction/construction management entity, and finally to the O&M entity. The responsibility for ensuring SOH features are provided and maintained on Reclamation facilities is spread across many Reclamation offices and disciplines which can lead to a lack of coordination and missed opportunities to maintain or improve SOH over the life of a facility.

Reclamation Design Criteria

Until 1994, Reclamation had well-defined engineering standards in the form of its Reclamation Instructions, design standards, design manuals, technical memoranda and other documents. Administrative policy and procedures for safety in relation to design was given in Reclamation Instructions Parts 131 and 365, and Design Standard No. 1, Chapter 3, *Safety Design Standards* [4]. Design Standard No. 1, Chapter 3, *Safety Design Standards*, was applicable to all projects and project features designed and constructed by Reclamation and identified specific technical and safety design criteria and/or provided references to which Reclamation design criteria or national code or standard was applicable to the facility under consideration. On May 18, 1993, Reclamation's Deputy Commissioner issued a memorandum that referenced these documents and stated that Reclamation facilities should comply with the life safety requirements contained in NFPA 101 and OSHA mandatory standards [7].

In 1994, a major reorganization took place that included the sunseting of all policies and standards contained in the Reclamation Instructions. Thereafter, Reclamation staff in the TSC and, to a lesser degree, in the regional, area, and field offices, used the sunsetted Reclamation Instructions as guidelines in providing engineering services and developed a few draft guidelines

between 1994 and 2000. In 2000, RM Policy *Performing Design and Construction Activities* (FAC P03) was issued and conveyed the authority to develop and implement engineering criteria to the TSC Director. Per FAC P03, the TSC Director is responsible for identifying, establishing, and maintaining design criteria, and engineering and technical standards for all Reclamation design work in order to promote consistent application of both Reclamation standards and current industry standards.

In its final report, “Managing for Excellence Action Item 16 – Bureau of Reclamation’s Engineering Standards,” dated December 2006, Team 16 identified recommendations that included improving Reclamation’s design standards. Since that time, Reclamation, predominantly the TSC, has been engaged in activities to review and update Reclamation design standards with a focus on the formal design standards, Design Standards No. 1 through 14.

Current Practice

Reclamation’s formal design standards and criteria present concise technical requirements and processes that enable design staff to prepare designs necessary to support the Reclamation mission. Compliance with these design standards assists in the development and improvement of Reclamation facilities in a way that protects the public’s health, safety, and welfare; recognizes all identified stakeholder needs; and achieves the lasting value and functionality necessary for Reclamation facilities. The responsible designer(s) accomplishes this through processes that enable compliance with Reclamation design standards and all other applicable technical codes, as well as incorporation of the stakeholder’s vision and values, that are then reflected in the construction project.

All Reclamation design work, whether performed by the TSC, regional or area offices, or an A-E firm, must conform to Reclamation design standards unless a deviation from the specific design criteria is requested and approved in accordance with FAC P03. Although Reclamation has steadily moved toward the integration of (or replacement by) available national standards in nearly all its design activities and internal design standards, it does maintain internal design standards as a means to capture the agency’s corporate experience, and to address cases where national standards do not exist, do not address Reclamation’s technical needs, or conflicts between requirements exist. Regional Directors and the TSC Director ensure that Reclamation criteria and standards are applied consistently for all design work performed by Reclamation personnel within their jurisdictions. The use of Reclamation criteria and standards for design activities performed by others which is funded (all or in part) with Reclamation funds or is performed on facilities owned by Reclamation (regardless of how such work is funded) is determined by the director having jurisdiction over the program, based on liability, financial, and other applicable issues.

Reclamation's use of its design standards requires that designers also integrate sound engineering judgment with applicable national standards, site-specific technical considerations, and project-specific considerations to ensure suitable designs are prepared, and protection of employee and public safety is not compromised. Designers are responsible for using the most current edition of referenced codes and standards and for being aware of how Reclamation Design Standards may include exceptions to requirements of these codes and standards. A general listing of internal and external SOH-related design criteria used by Reclamation designers is given in the Appendix.

RM D&S SAF 01-01 identifies the following documents for establishing safety and health standards for Reclamation:

- 29 CFR 1910 – Code of Federal Regulations, Occupational Safety and Health Standards, General Industry
- 29 CFR 1926 – Code of Federal Regulations, Occupational Safety and Health Standards for Construction
- DM 485 – Department of the Interior Safety and Occupational Health program
- Reclamation Safety and Health Standards (RSHS)

29 CFR 1910 and 29 CFR 1926 are comprehensive safety regulations addressing most hazards found in work and construction environments. For Reclamation designs, 29 CFR 1910 is generally used as the basis for design of walking and working surfaces, including stairs and ladders, and protection of openings. DM 485 is generally a guide for safety training and not directly applicable to designs. The RSHS, which references and supplements the requirements in 29 CFR 1926, prescribes safety and health requirements for all Reclamation activities and operations and states that Reclamation facilities must be operated and maintained in a manner that poses no excessive risk to the public. Its application to design is limited as it is focused on construction and operator safety, not designing out known hazards.

In Reclamation, life safety requirements for buildings and other structures must conform to the minimum requirements given in the current editions of the following codes:

- International Building Code (IBC)
- International Fire Code (IFC)
- National Fire Protection Association (NFPA 101), Life Safety Code Handbook

These codes provide minimum design requirements that regulate fire and life safety. However, they may overlap each other's provisions because each code has its specific means of classifying buildings according to use, occupancy, or hazard and one or more uses or occupancies may apply to a single structure. The IBC classifies buildings according to use and occupancy. The IFC emphasizes a reasonable level of life safety and property protection from hazards of fire,

explosion, and dangerous conditions. NFPA 101 stresses occupancy and hazard of contents. In addition to NFPA 101, NFPA also has guidelines that are specific to other occupancies such as NFPA 851 – *Recommended Practice for Fire Protection for Hydroelectric Generating Plants*.

Early in the final design stage, each designer identifies the codes and versions of codes that they will use as a basis of design for their assigned features. Where conflicting or contradictory provisions for life safety requirements are identified and the implementation of a particular measure cannot be decided at the PM/design team level, the AHJ must make a determination and provide written guidance to the design team. There is no formal process for identifying potential safety hazards beyond minimum SOH code compliance.

Evaluation

Reclamation design staff is very knowledgeable about their specific technical disciplines and design criteria; however, there is not a broad understanding of OSHA and life safety requirements. Expertise in OSHA safety and NFPA life safety requirements is generally limited to one or two individuals on the design team (typically the architect and/or engineer responsible for designing the miscellaneous metalwork for the job), and often these individuals are not engaged or are engaged too late, to provide meaningful input to the designs.

Since 1994, Reclamation designers have lacked an up-to-date, single source document that defines safety criteria to be used to design Reclamation facilities and have had to use numerous national codes and standards, outdated Reclamation design standards, and informal guidance documents at the service provider level to identify minimum safety requirements. Across these safety design criteria, interpretations must be made and it is sometimes difficult to reach consensus on which requirements should be applied to a facility. (For example, the protection of opening criteria found in 29 CFR 1910 is not adequate for facilities that will be open to the public and the more stringent criteria found in the IBC must be applied.) When conflicting criteria is identified, designers typically opt for the more conservative interpretation which may conflict with client and/or stakeholder interpretations, especially when costs of the more conservative interpretation are significant. To resolve these conflicts, the AHJ can be engaged to reach resolution.

Reclamation Design Process

Over the years, Reclamation has established clear processes to bring projects from planning through final design, to construction. A typical Reclamation design project goes through both planning design and final design phases.

Planning Design Phase

The requirements for planning level designs are described in Reclamation D&S and guidance documents. Appraisal designs are conducted to determine if there is at least one viable alternative that warrants a more detailed investigation through a feasibility study. Feasibility designs are detailed analyses of the technical and economic feasibility of a proposed project. The focus of these analyses is technical and economic viability. Since provisions for SOH are typically not major project cost drivers and do not jeopardize the technical viability of a project, SOH requirements are not generally well defined during the planning design phase.

Final Design Phase

FAC 03-03 and Reclamation's *Final Design Process Guidelines* (FDP Guidelines) are often used to manage the final design phase. The FDP Guidelines prescribe specific activities and milestones that should be accomplished to produce a well-coordinated final design package. At job initiation, Reclamation design service providers work with the PM to determine the scope, schedule, and budget for services. Significant communications and partnerships are required throughout the process to ensure the designers and clients collaborate fully to develop a design that meets the project objectives. Reclamation offices engaged in design and construction generally determine the type and number of design reviews.

The first opportunity for the design team to get a better understanding of the technical, operational, and safety needs of a project is in the development of, and response to, the design data request (DDR) which is used as a basis for guiding and completing designs. The DDR is prepared by the design team soon after the start of a design project and transmitted to the PM for coordination of the response to the DDR. The size and complexity of the facilities under consideration generally govern the amount and detail of the design data required. For many years Reclamation has used the Design Data Guidelines [3] to form the basis of this request. These 2007 guidelines provide a comprehensive listing of data to be collected for the preparation of feasibility and specifications (final) designs performed by or for Reclamation. The guidelines cover a wide range of project features and address issues that are critical to the successful completion of the necessary design activities. The predominant data collection efforts are focused on addressing technical requirements and constructability issues and do not specifically request identification of risks and hazards during construction, operation, or maintenance.

Communications between designers and clients occur throughout the final design process in order to produce a final product that addresses client needs and properly balances technical, operational, and SOH requirements; constructability; long-term serviceability; and economics. After the concept is defined to the 30% Final Design level (CONCEPTC), a Value Engineering (VE) Study is conducted to identify cost-effective alternatives for meeting project objectives. Acceptance or

rejection of the proposals developed by the VE team is jointly made by the design team and clients.

Draft specifications paragraphs and drawings are reviewed by all involved parties at the 90% Final Design level (SPEC'D) and a meeting to discuss comments is held (REVIEWC). This review provides a final opportunity for a comprehensive review of the designers' products to ensure they meet client needs and are constructable. REVIEWC participants typically include the design team, PM, representatives from the construction office, and end users. Reclamation's safety community is normally engaged to review the safety sections in the specifications package (sections 01 35 10 [Safety Data Sheets] and 01 35 20 [Safety and Health]), but rarely does the safety professional review the drawings to ensure that adequate SOH measures have been included in the final design concept.

Construction Phase

During construction, Reclamation staff is focused on ensuring compliance with final specifications plans and drawings. Revisions to the specifications to account for changed site conditions, furnished equipment, and/or conflicting or missing information in the specifications package can occur. Minor changes in designs with no cost impacts are often communicated to designers informally prior to directing the contractor to proceed. More significant changes to designs that may represent a deviation from the intent of the designers' operating criteria or the intent of the original design are communicated to the responsible designers and a formal modification is prepared to direct the contractor's activities. All changes during the construction phase are documented in as-built drawings in accordance with FAC 03-02.

At the conclusion of construction, various walkthrough inspections are conducted by the construction management staff and the contractor to verify compliance with the specifications. Participation on the transfer inspections from construction to O&M status is determined by the construction office and typically includes representatives from design, construction, and the end user (FAC 01-05). For modification work on existing facilities that remain in O&M status throughout construction, a similar walkthrough inspection should occur (FAC 03-02).

Post-Construction (O&M) Phase

During the course of operations it may be necessary to modify existing facilities to improve operations or replace equipment. Modifications to Reclamation facilities where there is a deviation from the intent of the designers' operating criteria or the intent of the original design are referred to the responsible design organization.

Evaluation

Communication among designers, project personnel, and clients is essential to produce a sound and balanced final design product. Currently the design process focuses on meeting minimum SOH code requirements. There is no process for identifying and eliminating or mitigating for hazards early in the design process when safety measure improvements could most cost-effectively be incorporated. Although O&M requirements are a part of the initial design data request, the DDR's primary focus is on acquiring data needed to define, design, and construct facilities. Reclamation's Design Data Guidelines currently do not specifically address the client's preference to put in place measures above minimum code requirements to improve the safety of construction and future O&M activities. For instance, there are no questions pertaining to the client's preference on the purchase of "Buy Quiet" equipment and there are no specific requests for information pertaining to safety features that would facilitate future inspections, maintenance and operations.

The FDP Guidelines do not include a step for evaluation of SOH hazards and risk assessment in construction, use, operation or maintenance. Reclamation's focus during the design phase is on technical adequacy, project economics, and constructability of the project, as well as meeting design budget and schedule commitments. Too much focus on reducing project costs during design can have negative impacts on safety provisions that are considered "nice-to-haves" in lieu of "need-to-haves" (such as reducing space around equipment to code minimums). Acceptance of VE proposals do not always consider possible negative impacts to SOH. Designers may also receive pressure from clients to use a less stringent interpretation of differing code requirements in order to reduce construction costs. Construction personnel are not integrated into the design process for the specific purpose of identifying construction hazards or potential safety features that could reduce the risk of injury in the construction process.

The draft specifications review between SPECD and REVIEWC is typically focused on missing and contradictory provisions of the specifications and constructability. Direct participation of staff charged with future O&M of the facilities is often overlooked, as is a comprehensive SOH review of the facility by a safety professional. From a design efficiency standpoint, clear SOH requirements and recommendations on how to improve SOH of the facility should be made much earlier than during the draft specifications review to avoid significant rework and negative design schedule and cost impacts.

During construction, the contractor and Reclamation construction management staff are responsible for the safety of construction activities. Construction personnel generally accept the design as provided and construct the project as safely as possible. Changes during construction are generally communicated to the responsible designers prior to enactment. The changes recommended by construction personnel are generally regarding constructability. At the conclusion of construction, a transfer inspection with participation from the design, construction,

and O&M communities provides an opportunity to identify lessons learned and possible future actions to improve the SOH of the facilities. There is no clear, consistent process for communicating lessons learned back to designers that could improve safety in construction.

During the O&M stage, the question of when changes by O&M staff constitute changes to original design intent is not always well understood and there is no clearly defined process for facility managers to engage design staff prior to enacting these modifications. Without a timely way of getting technical input on proposed changes, modifications that inadvertently reduce the SOH of the facility are possible. There are also missed opportunities to incorporate improved SOH measures as part of the modification work.

Life Safety Code Compliance in Other Agencies

Similar to Reclamation, there are other government agencies that incorporate SOH requirements into the design and construction of their facilities.

U.S. General Services Administration (GSA)

The Public Building Amendment of 1988, 40 USC 3312 requires that each building constructed or altered by GSA or any other federal agency shall to the maximum extent feasible be in compliance with one of the nationally recognized model building codes. GSA has adopted the technical requirements of the family of codes issued by the International Code Council which include the IBC and IFC to supplement other GSA requirements by Federal law and Executive Order. Additionally, GSA has adopted the technical egress requirements of NFPA 101. The AHJ for GSA is the Regional Fire Protection Manager who has responsibility for all GSA buildings within a region.

U.S. Army Corps of Engineers (USACE)

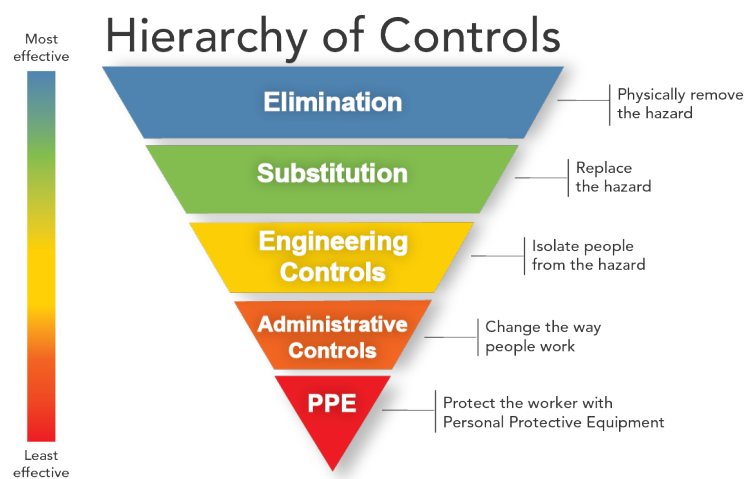
According to the Life Safety Code Compliance Review Report [2], the U.S. Army Corps of Engineers does not have a specific life safety program. Life Safety decisions are made by the Commanding Officer of the District or at the particular military installation where the USACE is operating. Engineering Manual No. 385-1-1 (EM-385-1-1), *Safety and Health Requirements*, dated September 2008, prescribes the safety and health requirements for all USACE activities and operations, and references 29 CFR 1910 and 29 CFR 1926. Engineering Manual No. 1110-2-3001 (EM-1110-2-3001), *Planning and Design of Hydroelectric Powerplant Structures*, dated April 30, 1995 references the NFPA codes for life safety.

National Park Service

According to the Life Safety Code Compliance Review Report [2], the National Park Service (NPS) is charged with preserving and protecting human life and the resources entrusted to its management. These resources include buildings and structures, irreplaceable cultural resources, valuable property, and infrastructure. Its Structural Fire program provides service-wide policy standards, operational procedures, and accountability. The program ensures that all areas within the system have an appropriate level of structural fire protection that is provided in a safe and cost effective manner by qualified personnel; it also addresses the implementation of LSC requirements for the National Park Service. The NPS has adopted the minimum standards of NFPA 101 for life safety designs for buildings and Regional Directors are designated as the AHJ within their respective Regions.

Safety through Design

Hierarchy of controls is a systematic approach to avoiding, eliminating, controlling, and reducing risks. The process considers steps in a ranked and sequential order beginning with elimination and substitution. Residual risks are controlled using engineering controls, warning systems, administrative controls, and PPE. The hierarchy is intended to demonstrate that the control methods at the top of the ranking are more effective and protective than those ranked lower. A major reason that the controls are ranked in this order is that elimination removes the potential for human error, the hazard does not exist. As the design solution moves down the controls scale, more processes must be followed when performing the work resulting in a greater risk of human error that could result in injury. The goal is to reduce the risk of injury to an acceptable level.



The National Institute for Occupational Safety and Health (NIOSH)

Safety through Design focuses on using the design process to eliminate or “design out” hazards as the ultimate goal. It encompasses all the efforts to anticipate and design out hazards to workers during construction, work methods, operations, maintenance, processes, and equipment. It includes programs that focus on risks to construction workers (Design for Construction Safety or DfCS) and programs focused on risks to construction workers and the people who will later use the facilities (Prevention through Design or PtD). Safety through Design looks beyond the minimum requirements found in building and life safety codes to improve the safety of a facility over its’ lifecycle through smart planning and smart design.

PtD aims to lower risks for workers by eliminating or reducing hazards as early as possible in the life cycle of equipment and facilities. An example of hazard avoidance is to design equipment in a facility so that a portable ladder is not needed for O&M. If it is not possible to design the equipment so that it can be operated and maintained from ground level, then the design should include a fixed ladder or platform with stairs to eliminate the hazard of using a portable ladder.

Obviously it is not possible to design out all hazards and in these instances PtD focuses on substituting the safest practical option. For hazards that cannot be eliminated, the next line of defense is engineering controls. This requires physical changes to isolate users from hazards. Engineering controls often require additional measures to keep users safe. Administrative controls require an owner or employer or employee to follow special procedures to safely use a facility or perform a procedure. Administrative controls also require an understanding of the purpose and proper use of engineering controls. Personal protective equipment (PPE) requires a worker to wear special equipment to safely perform their work. PPE also requires a worker to have an understanding of engineering and administrative controls.

An example of an engineering control is a gate and signage used to keep workers away from hazardous equipment. An Administrative control is the training required for workers who must use or maintain the equipment beyond the gate. PPE is the equipment the worker must wear to safely operate or maintain that equipment.

Thinking about hazards in this manner makes it clear that as mitigation for hazards moves down the hierarchy of controls, the risk of injury or worse increases because the potential for human error increases. PPE is considered the least effective way to manage hazards because more and more of the responsibility for safety is placed on workers. People may not understand instructions, be tired, or distracted. The risk of injury goes up as the level of specialized knowledge and complexity of safety procedures goes up.

The best way to prevent and control occupational injuries, illnesses, and fatalities is to “design out” hazards to reduce risks. The greatest opportunities for eliminating or minimizing hazards is to consider SOH as early as possible in the life cycle of equipment and facility design. A hazard

assessment can identify potential hazards to the people who will construct them and use them in any capacity. The ultimate goal of PtD is to prevent or reduce occupational injuries, illnesses, and fatalities through the inclusion of prevention considerations into all designs.

Formal Safety through Design programs began slowly gaining attention in the United States in the late 1990s. There are two primary programs in the United States leading this effort. National Institute for Occupational Safety and Health (NIOSH) has assisted in organizing the Prevention through Design (PtD) program. PtD focuses on designing out hazards associated with use, operation and maintenance. OSHA sponsored Alliance Construction Roundtable promotes Design for Construction Safety (DfCS) which focuses primarily on design considerations to make projects safer for construction workers. In 2011, The American National Standard Institute (ANSI) published ANSI/ASSE Z590.3-2011, *Prevention through Design Guidelines for Addressing Occupational Hazards and Risks in Design and Redesign Processes* [8].

National Institute for Occupational Safety and Health (NIOSH)

In July 2007, NIOSH sponsored its first PtD Workshop. In partnership with many organizations representing industry, labor, government and associations focused on the advancement of health and safety research, NIOSH has continued to promote the PtD initiative. NIOSH defines PtD as follows:

PtD encompasses all of the efforts to anticipate and design out hazards to workers in facilities, work methods and operations, processes, equipment, tools, products, new technologies, and the organization of work. The focus of PtD is on workers who execute the designs or have to work with the products of the design. The initiative has been developed to support designing out hazards, the most reliable and effective type of prevention.

The goal of a PtD program is to avoid bringing hazards into a workplace or eliminate hazards through design. The focus is on identifying hazards then using the “hierarchy of controls” to reduce risk of injury to an acceptable level. After risks have been minimized to the greatest extent practical through design, engineering and administrative controls, PPE should be employed to further reduce risk of injury.

In November 2014, NIOSH released publication number 2014-123 titled *The State of the National Initiative on Prevention through Design* [9] which provides a current overview of progress made since the 2007 workshop in the areas of research, education, practice, and policy initiatives. In addition, the NIOSH website (<http://www.cdc.gov/niosh/topics/ptd/default.html>) contains information on PtD programs and links to a wide variety of general and industry specific publications and training materials.

Occupational Safety and Health Administration (OSHA) - Design for Construction Safety

OSHA coordinates groups of various industry volunteers interested in variety of safety issues called Alliance Workgroups. In 2004, OSHA recognized that there was a very active group of program participants with a common interest in construction-related issues. OSHA assembled the Alliance Construction Roundtable. Initially, two distinct workgroups were established: Fall Protection, and Design for Safety. Over time the workgroups realized that there was added benefits to meeting jointly and in 2009 the individual workgroups disbanded and collectively the members focused more broadly on construction industry safety and health issues.

The Alliance Construction Roundtable promotes and makes educational materials available on their DfCS program. Similar to PtD, the program promotes consideration of safety at the conceptual design phase. A primary difference between the DfCS and PtD programs is that DfCS focuses exclusively on design considerations for safety during construction.

Information on the DfCS program can be found at

https://www.osha.gov/dcsp/alliances/roundtables/roundtables_construction.html#top. The website also has training information developed through the Roundtable. It is important to note that educational materials produced by the Roundtable are not OSHA requirements, but are best practice recommendations assembled by industry leaders in construction safety.

American National Standards Institute (ANSI) – Prevention through Design (PtD)

In 2011, the American National Standard Institute (ANSI) published ANSI/ASSE Z590.3-2011 [8]. This standard was developed to provide consistent procedures for addressing occupational hazards and risks in the design and redesign processes. It provides guidance on including prevention through design concepts within an occupational safety and health management system. It pertains principally to the avoidance, elimination, reduction, or control of occupational safety and health hazards and risks in the design and redesign processes. ANSI defines PtD as a process for addressing occupational safety and health needs in the design and redesign process to prevent or minimize the work-related hazards and risks associated with the construction, manufacture, use, maintenance, retrofitting, and disposal of facilities, processes, materials, and equipment.

Conclusions

The Team concludes the following:

- The responsibility for ensuring SOH features are provided and maintained at Reclamation facilities is identified and applied across many Reclamation documents, organizations, and disciplines which can lead to a lack of coordination and missed opportunities to cost-effectively improve the SOH of facilities during design.
- Reclamation has strong safety, design, and construction cultures. While the safety organization is well integrated into the construction process, it is not well integrated into the design process. Further, the responsibilities of the Authority Having Jurisdiction (AHJ) are not well understood across the agency.
- The sunset of Reclamation policy in 1994 has created a void in internal safety design guidance that has not been properly addressed by current Reclamation Manual (RM) [1] documents and design criteria. No clear guidance is available to assist designers in Reclamation specific design criteria and the incorporation of national standards into design work.
- Reclamation has a well-defined final design process (FDP) that is focused on technical adequacy, constructability, and cost. Generally designers and project owners consider SOH a high priority; however there is no formal process during final design for identifying potential hazards in construction, operation, maintenance and decommissioning; evaluating risks associated with the hazards; and assessment of design options to potentially eliminate or mitigate for SOH hazards.
- The success of improving the overall safety of Reclamation facilities requires effective communication, coordination, and collaboration among Reclamation's safety, design, construction, and O&M communities, and strong support from the RLT.
- One of the best ways to prevent and control occupational injuries, illnesses, and fatalities is to "design out" hazards. Prevention through Design (PtD) is a formal approach using hierarchy of controls and risk assessment to identify project hazards early in the design process and working to eliminate these hazards, or find design alternatives that mitigate the hazard so the risk of injury is at an acceptable level.
- Implementation of a formal PtD program is one additional step Reclamation can take to help improve the SOH of our facilities. To be effective, SOH measures incorporated in the initial designs need to remain in place and/or be modified as necessary during the life of the facility.

Recommendations

Safety Action Team 20 recommends the following actions be considered for implementation by Reclamation's Leadership Team:

1. Revise the RM [1] as follows:
 - a. Create a new D&S under SAF P01 identifying AHJ responsibilities. (See Appendix G of the 2008 Life Safety Code Compliance Review Report [2]).
 - b. Revise D&S FAC 01-05 to require participation of a safety professional on transfer inspection teams.
 - c. Revise FAC 03-03 to identify AHJ design responsibilities and a clear means to integrate AHJs into the design process.
2. Assign a team to review and revise Reclamation's Design Data Collection Guidelines [3] to increase focus on design provisions to improve safety and health practices during construction and operations, and to solicit client and stakeholder input regarding SOH preferences above minimum requirements. Include identification of existing hazards (energy, materials, access, etc.), identification of hazards during construction, required contractor safety representation during construction, and identification of post-construction hazards.
3. Maintain focus on Reclamation formal design standard updates and include SOH information in Design Standards No. 1 through 14 as appropriate.
4. Establish a team to prepare a "Reclamation Safety Design" guidance document that can be used by designers to complement existing Reclamation and national standards they currently use to perform their work. This document could be modeled after Design Standard No. 1, Chapter 3, *Safety Design Standards* [4] and should identify feature specific minimum safety criteria with references to appropriate codes. It should be prepared by a team with representation from Reclamation's design, construction, O&M, and safety communities.
5. The RLT should institute a Reclamation-wide PtD program and establish a PtD Implementation Team. The goal of the PtD Implementation Team would be to integrate PtD into Reclamation's design process to identify hazards, evaluate methods to avoid and/or eliminate identified hazards, or reduce the risks to acceptable levels. The team should have representation from Reclamation's design, construction, O&M, and safety communities. Once established, the PtD Implementation Team should:

- a. Develop Reclamation facility-specific Hazard Review Checklists for designers and other SOH review team members to use in PtD hazard risk assessments. The Checklists should include an assessment of the potential for noise-induced hearing loss of occupants that could be mitigated through application of “Buy Quiet” principles.
 - b. Conduct a comprehensive review of historical accident and near-miss reports. For incidents where a design weakness/deficiency caused or contributed to the incident, the design deficiency should be included in the Hazard Review Checklist. If a design or process modification was implemented to eliminate or mitigate the hazard, this corrective action information should also be documented.
 - c. Formalize a process for gathering lessons learned during construction and operation of facilities from design, construction, O&M, and safety personnel. Lessons learned that make future projects safer should be included in the Hazard Review Checklist.
 - d. Develop guidance documents and conduct training to facilitate integration of PtD into Reclamation’s design culture.
6. Request the Reclamation Design and Construction Coordination Team (RDCCT) to revise the Final Design Process (FDP) Guidelines to include:
 - a. PM formation of a SOH review team comprised of representatives from design, construction, safety, O&M, and others with specialized knowledge of the project to conduct a PtD hazard risk assessment during final design to consider SOH in construction, operation, and maintenance.
 - b. Creation of a Milestone for PtD hazard risk assessment near the 30% Final design milestone (CONCEPTC).
 - c. O&M staff participation during the draft specifications review stage (REVIEWC) to focus on SOH provisions.
 - d. Safety Office personnel participation during the draft specifications review stage (REVIEWC) to not only focus on construction safety, but also operator safety.
 - e. Creation of a milestone for Post-Project Review to gather lessons learned and identify SOH improvements for future, similar facilities.
7. Request the Facilities Operation and Management Team to work with the RDCCT to establish a well-defined, efficient process for O&M personnel to obtain input from Reclamation’s design community when they are contemplating field modifications that could represent a deviation from the original design intent. The process should permit

an opportunity for a Reclamation safety professional to evaluate possible impacts the modifications may have on the SOH of the facility.

References

- [1] Reclamation Manual, <http://www.usbr.gov/recman/>, April 2015.
- [2] Life Safety Code Compliance Review Report, Bureau of Reclamation, Security, Safety and Law Enforcement, July 2008 (Transmitted to RLT on December 18, 2008 by Dave Achterberg)
- [3] Reclamation's Design Data Collection Guidelines,
<http://intra.usbr.gov/~tsc/guidance/design/designdata.html>
- [4] Design Standard No. 1, Chapter 3, *Safety Design Standards*,
<http://intra.usbr.gov/~tsc/techdocs/design-standards-archive.html>
- [5] Safety and Occupational Health (SOH) Action Plan, Bureau of Reclamation, May 2014.
- [6] Memorandum from SSLE Director to Reclamation Leadership Team, Subject: Life Safety Code (LSC) Implementation Plan (Action by December 3, 2010), dated November 24, 2010.
- [7] Memorandum from Deputy Commissioner to Assistant Commissioners and Regional Directors, Subject: Applicability of Life safety Code to Bureau of Reclamation Designs and Facilities (Safety Policy), dated May 18, 1993.
- [8] ANSI/ASSE Z590.3 – 2011 Prevention through Design – Guidelines for Addressing Occupational Hazards and Risks in Design and Redesign Processes
- [9] The State of the National Initiative on Prevention through Design (NIOSH), May 2014.
<http://www.cdc.gov/niosh/docs/2014-123/>

Appendix: Safety and Occupational Health Related Design Criteria

Reclamation SOH Design Criteria

- A. Reclamation Design Standards No. 1 through 14
- B. Reclamation Safety and Health Standards (RSHS)
- C. Facilities Instructions, Standards, and Techniques (FIST)
 - 1. Transformer Fire Protection, Volume 3-32
 - 2. Safety, Volume 5

Federal SOH Design Criteria

- A. 29 CFR 1910 – Code of Federal Regulations, Occupational Safety and Health Standards, General Industry
- B. 29 CFR 1926 – Code of Federal Regulations, Occupational Safety and Health Standards for Construction
- C. Architectural Barriers Act Accessibility Standards (ABAAS)

National SOH Design Criteria

- A. International Code Council (ICC):
 - 1. International Building Code (IBC)
 - 2. International Fire Code (IFC)
 - 3. International Plumbing Code (IPC)
 - 4. International Mechanical Code (IMC)
- B. National Fire Protection Association (NFPA)
 - 1. Life Safety Code Handbook, NFPA 101
 - 2. Recommended Practice for Fire Protection for Hydroelectric Generating Plants, NFPA 851
 - 3. National Electric Code, NFPA 70
 - 4. Standard for Electrical Safety in the Workplace, NFPA 70E
- C. American National Standards Institute
 - 1. Occupational Health and Safety Management Systems, ANSI Z10
- D. Applicable Codes from the following organizations:
 - 1. American Society of Mechanical Engineers, ASME
 - 2. National Electrical Manufacturer's Association, NEMA
 - 3. Institute of Electrical and Electronic Engineers, IEEE